CLAIMS

1. A lens system having an axis, comprising:

a first lens group having positive refractive power;

a second lens group positioned forward the first lens group along the axis and having negative refractive power, the second lens group comprising one or more zoom lenses;

a third lens group having positive refractive power and positioned forward the first and second lens groups along the axis; and

wherein at least one zoom lens is movable along the axis, enabling a laser transmitted through the lens system to be focused at different depths, such that the lens system is capable of scanning a laser focused with a spot size of less than about 3 microns over a field having a diameter of at least about 9 mm at the different depths.

2. The lens system of claim 1, wherein the lens system has a nominal focal length, and wherein the different depths to which the laser is transmitted through the lens system may be focused using the one or more zoom lenses over a range from at least about +1 mm to at least about -1 mm from the nominal focal length of the lens system.

3. The lens system of claim 1, wherein the lens system has a focal length, and further comprising a fourth lens group movable between a first position along the axis and a second position out of alignment with the axis, the fourth lens group in the first position being placed between the second and third lens groups to increase the focal length of the lens system.

4. The lens system of claim 3, wherein the lens system has a viewing field that is increased to at least about 25 mm when the fourth lens group is in the first position.

5. The lens system of claim 3, wherein the lens system has a viewing field that is increased to at least about 30 mm when the fourth lens group is in the first position.

6. The lens system of claim 3, wherein the lens system has a working distance that is greater than about 100 mm when the fourth lens group is in the first position.

7. The lens system of claim 3, wherein the fourth lens group has negative refractive power.

8. The lens system of claim 6, wherein the fourth lens group comprises a lens doublet.

9. The lens system of claim 1, wherein the lens system has a working distance that is greater than about 36 mm.

10. The lens system of claim 1, wherein the lens system has a scanning field that has a field flatness of less than about 10 microns.

11. The lens system of claim 1, wherein the laser is a femtosecond laser.

12. The lens system of claim 11, wherein the femtosecond laser is used in laser eye surgery.

13. The lens system of claim 11, wherein the femtosecond laser is the Pulsion™ FS laser.

14. The lens system of claim 1, wherein the laser is employed to cut a flap in the cornea of the eye.

15. A lens system having an axis, comprising:

a first lens group having positive refractive power;

a second lens group positioned forward the first lens group along the axis and having negative refractive power, the second lens group comprising one or more zoom lenses;

a third lens group having positive refractive power and positioned forward the first and second lens groups along the axis; and

wherein at least one zoom lens is movable along the axis such that a laser transmitted through the lens system may be focused over a range of depths while maintaining diffraction-limited performance and a numerical aperture of at least about 0.3 at a working distance of greater than about 36 mm.

16. The lens system of claim 15, wherein the laser transmitted through the lens system can be scanned over a field having a diameter of at least about 9 mm over the range of depths.

17. The lens system of claim 15, wherein the lens system has a nominal focal length, and wherein the range of depths to which the laser is transmitted through the lens system is at least about +1 mm to at least about -1 mm from the nominal focal length of the lens system.

18. The lens system of claim 15, wherein the laser is a femtosecond laser.

19. The lens system of claim 18, wherein the femtosecond laser is the Pulsion™ FS laser.

20. The lens system of claim 15, wherein the lens system has a focal length, and further comprising a fourth lens group movable between a first position along the axis and a second position out of alignment with the axis, the fourth lens group in the first position being placed between the second and third lens groups to increase the focal length of the lens system.

21. The lens system of claim 20, wherein the lens system has a viewing field that is increased to at least about 25 mm when the fourth lens group is in the first position.

22. The lens system of claim 20, wherein the lens system has a viewing field that is increased to at least about 30 mm when the fourth lens group is in the first position.

23. The lens system of claim 18, wherein the lens system has a focal length, and wherein the focal length is increased to greater than about 100 mm when the fourth lens group is in the first position.

24. The lens system of claim 15, wherein the lens system has a ratio of the change in the depth of focus to the movement of the zoom lens that is close to 1 to 1.

25. A method of performing laser eye surgery, comprising:

focusing a laser with a lens system having at least one zoom lens to a predetermined position in the cornea of an eye of a patient;

scanning the laser over a predetermined scanning path in the cornea to cut a corneal flap in the eye,

wherein the scanning path includes a range of depths, and zooming the focus of the laser at different depths is performed using the at least one zoom lens of the lens system.

26. The method of claim 25, wherein the focused laser has a spot size of less than about 3 microns.

27. The method of claim 25, wherein the scanning path is associated with a scanning field having a diameter of at least about 9 mm.

28. The method of claim 25, wherein the cutting of the corneal flap comprises:

focusing the laser to a specific depth within the cornea;

delivering the laser to multiple spots positioned close together to form a spiral pattern, creating an incision at the specific depth; and

creating a stack of arc-patterned paths about the periphery of the spiral patterned cut by:

zooming the focus of the laser to different depths ranging from the specific depth of the incision to the surface of the cornea.

29. The method of claim 28, further comprising:

increasing the focal depth and viewing field of the lens system so that the focal depth and viewing field are sufficiently large to enable a magnified image of the corneal flap of the eye to be viewed while having sufficient space between the lens system and the eye to allow a surgical instrument or hand to manipulate the corneal flap.

30. The method of claim 28, wherein the cutting at the specific depth has a field flatness of less than about 10 microns.

31. The method of claim 25, further comprising:

inserting a lens group within the lens system to allow viewing of the eye through the lens system and increase the working distance of the lens system.

32. The method of claim 31, wherein the insertion of the lens group provides sufficient space between the lens system and the patient's eye to allow manipulation of the corneal flap with an instrument.

33. The method of claim 25, further comprising:

positioning a lens group within the lens system to allow viewing of the eye and to increase the working distance of the lens system to greater than about 100 mm.

34. The method of claim 33, wherein the positioning of the lens group within the lens system increases the viewing field to greater than about 25 mm.

35. The method of claim 34, wherein the positioning of the lens group within the lens system increases the viewing field to greater than about 30 mm.

36. The method of claim 35, further comprising:

focusing the laser at a working distance of at least about 36 mm so that the system of lenses will not interfere with the patient's nose.

37. The method of claim 25, wherein the lens system has a nominal focal length, and wherein the range of depths to which the laser may be focused is from at least about +1 mm to at least about -1 mm from the nominal focal length of the lens system.

38. The method of claim 25, wherein the laser is a femtosecond laser.

39. The method of claim 38, wherein the femtosecond laser is the Pulsion™ FS laser.

40. A lens system for use in laser eye surgery comprising:

a first lens group having positive refractive power;

a second lens group positioned forward the first lens group and having negative refractive power and comprising a zoom lens;

a third lens group having positive refractive power and positioned forward the first and second lens groups;

a fourth lens group movable between a position between the second and third lens groups and a position away from the second and third lens groups such that when the fourth lens group is positioned between the second and third lens groups, the focal depth and viewing field of the lens system increases;

wherein the lens system is capable of: operating at a working distance of greater than about 36 mm; scanning a field having a diameter of at least about 9 mm;

focusing a laser with a spot size of less than about 3 microns; and having a numerical aperture of greater than about 0.3 over the entire scanning field; and

wherein the zoom lens is movable along the principle optical axis of the lens system such that a femtosecond laser transmitted through the lens system may be focused at different depths ranging from at least about +1 mm to at least about -1 mm from the nominal focal length of the lens system.

41. A lens system, substantially satisfying the following chart:

Lens	Surface	r (mm)	t1 (mm)	t2 (mm)	N	V	d (mm)
L1	1	310.254	6.25 ± .05		1.62041 ±.0002	60.32 ±.01	63.91
	2	-865.592		.051 +.020 or -.05			63.94
L2	3	71.8605	9.75 ± .05		1.78831 ±.0002	47.47 ±.01	63.69
	4	278.115		8.260 ± .05			61.58
L3	5	-300.853	2 + .01 or - .042		1.66446 ±.0002	35.83 ±01	58.22
	6	58.781		46.740 ± .05			55.70
L4	7	-71.835	24.361 + .010 or -.002		1.78831 ±.0002	47.47 ±.01	63.45
	8	-81.295		1.643 + .009 or -.041			75.66
L5	9	130.107	15.4 +.005 or -.025		1.62041 ±8.5e-5	60.32 ±.01	78.31
	10	-156.501		.051 +.006 or -.028			77.55

L6	11	80.908	10.25 +.014 or -.05		1.66446 ±.0002	35.83 ±.01	71.42
	12	235.496		.035 +.015 or -.003			67.71
L7	13	41.666	16.8 + .037 or -.012		1.62041 ±.0002	60.32 ±.01	59.38
	14	-743.185	0.03		1.51680 ±.0001	64.17 ±.01	51.45
L8	15	-743.506	2.200 +.010 or -.046		1.78472 ±.0002	25.76 ±.01	51.41
	16	29.521		44 ± .05			40.62
L9	17	34.735	10.1				48.30
	18	45.15	11.003				44.0
L10	19	-72.12	2				42.4
	20	60.17	14				43.4

wherein: r is the radius of curvature of an individual lens surface; t1 is the lens thickness; t2 is the aerial lens-to-lens distance; N is the refractive index of an individual lens; V is the abbe number of the lens glass; and d is the diameter of an individual lens surface.

42. The lens system of claim 41, wherein tolerances associated with parameters of the lens system are substantially as shown in the following tables:

Lens	Surface	r: Power (fringes)	r: Irregularity (waves)	surface decenter x (mm)	surface decenter y (mm)	surface TIR x (mm)	surface TIR y (mm)
L1	1	4	0.2	± .05	± .05	.005	.005
	2	4	0.2	± .05	± .05	.005	.005
L2	3	4	0.2	± .0071955	± .0071936	.005	.005

	4	4	0.2	± .028266	± .028274	.005	.005
L3	5	3.5747	0.2	± .013228	± .013228	.0025716	.0025716
	6	3.6417	0.2	± .029432	± .029432	.0028015	.0028015
L4	7	3.865	0.2	± .037273	± .037273	.0033586	.0033586
	8	3.2172	0.2	± .0030108	± .0030109	.0028606	.0028606
L5	9	4	0.2	± .0058993	± .0059003	.0036413	.003642
	10	2.9502	0.2	± .0042619	± .0042624	.0021763	.0021765
L6	11	4	0.2	± .011826	± .011826	.005	.005
	12	4	0.2	± .014127	± .014128	.0041844	.0041846
L7	13	4	0.2	± .0026876	± .0026871	.0039213	.0039206
	14	4	0.2	± .05	± .05	.005	.005
L8	15	4	0.2	± .003153	± .0031524	.0044445	.0044437
	16	4	0.2	± .05	± .05	.005	.005

Lens	element decenter x (mm)	element decenter y (mm)	element tilt x (degrees)	element tilt y (degrees)
L1	± .05	± .05	± .019337	± .019333
L2	± .0080018	± .0079994	± .0057032	± .0057029
L3	± .0024825	± .0024825	± .0041356	± .004135
L4	± .014185	± .014186	± .029466	± .029466
L5	± .0024791	± .0024794	± .0049561	± .0049558
L6	± .013323	± .013323	± .003873	± .0038727
L7	± .0097664	± .0097667	± .0071825	± .0071814
L8	± .05	± .05	± .05	± .05

wherein TIR is the total indicator runout of a surface.